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Indian Standard

SPECIFICATION FOR POWER TRANSFORMERS

PART IV TERMINAL MARKINGS, TAPPINGS AND CONNECTIONS

(First Revision)

(Incorporating Amendment Nos. 1 & 2)

UDC 621.314.222.6 : 621.315.684 - 777

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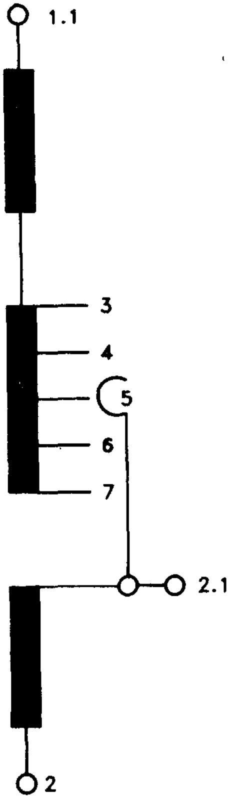
AMENDMENT NO. 2 SEPTEMBER 1993
TO
IS 2026 (Part 4) : 1977 SPECIFICATION FOR POWER TRANSFORMERS

PART 4 TERMINAL MARKING, TAPPINGS AND CONNECTIONS

(First Revision)

(*Page* 8, *Fig.* 3b) — Substitute the following for the existing:



(ETD 16)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 1 DECEMBER 1984
TO
IS:2026(Part 4)-1977 SPECIFICATION FOR POWER TRANSFORMERS
PART 4 TERMINAL MARKINGS, TAPPINGS AND CONNECTIONS

(First Revision)

(*Page 12, clause 3.1.6*) - Substitute the following for the existing clause:

"3.1.6 Requirements Related to Temperature-Rise (Gurantees and Tests) - Temperature-rise limit values are applicable to the tapping position as specified in 3.4 of IS:2026(Part 2) 1977 'Specification for power transformers, Part 2 Temperature-rise'. Except in such cases where agreed to between the purchaser and the supplier, the temperature-rise test need be carried out on one tapping only, chosen in accordance with 3.4 of IS:2026 (Part 2)-1977."

(*Page 12, clause 3.2.2.2, Note 2*) - Delete.

(ETDC 16)

Printed at Dee Kay Printers, New Delhi, India

IS : 2026 (Part IV) - 1977

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SPECIFICATION FOR POWER TRANSFORMERS

PART IV TERMINAL MARKINGS, TAPPINGS AND CONNECTIONS

(First Revision)

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(*Continued on page* 2)

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Indian Standard

SPECIFICATION FOR POWER TRANSFORMERS

PART IV TERMINAL MARKINGS, TAPPINGS AND CONNECTIONS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part IV) (First Revision) was adopted by the Indian Standards Institution on 24 February 1977, after the draft finalized by the Transformers Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This revision of IS : 2026-1962* has been undertaken with a view to bringing it in line with the revision of IEC Pub 76-1967 'Power transformers'.

0.3 In this revision the requirements for power transformers are covered in four parts as follows:

Part I General,

Part II Temperature-rise,

Part III Insulation levels and dielectric tests, and

Part IV Terminal markings, tappings and connections.

0.4 This standard (Part IV) has been based on IEC document 14 (Central Office) 26 revision of publication 76 : 'Power transformers, terminal and tapping markings for power transformers' and IEC document 14 (Central Office) 28 revision of publication 76 : 'Power transformers, tappings and connections for power transformers', issued by the International Electrotechnical Commission.

0.5 In this revision the phase markings UVW has been adopted in place of ABC in line with the international practice.

0.6 This part shall be read in conjunction with IS : 2026 (Part I)-1977†, IS : 2026 (Part II)-1977‡, and IS : 2026 (Part III)-1977§.

0.7 This edition 2.2 incorporates Amendment No. 1 (December 1984) and Amendment No. 2 (September 1993). Side bar indicates modification of the text as the result of incorporation of the amendments.

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*Specification for power transformers.

†Specification for power transformers: Part I General (*first revision*).

‡Specification for power transformers: Part II Temperature-rise (*first revision*).

§Specification for power transformers: Part III Insulation levels and dielectric tests (*first revision*).

1. SCOPE

1.1 This standard (Part IV) covers terminal markings, tappings and connections for power transformers.

2. TERMINAL AND TAPPING MARKINGS

2.1 Method of Identifying Terminals and Tappings of Power Transformers

2.1.1 *Characters* — An alternate sequence employing capital (upper case) Roman letters and one or more Hindu-Arabic numeral characters shall be used for marking the terminals and tappings of power transformers. The letters '*I*' and '*O*' shall not be used.

2.1.1.1 In a complete marking, the letters and numeral characters which are not required for clear identification, may be omitted. Should numeral character groups having different significance be immediately adjacent to each other, they shall, to avoid confusion, be separated by a full stop. For example, if in 1 *U*11, *U* is not required, 1.11 would be the abbreviated notation.

2.1.2 *End Points of Phase-Windings* — The two end points of phase-windings which lead to line or neutral terminals shall be marked by the reference numbers 1 and 2.

Where phase-windings have at their ends tappings which are to be connected to on-load tap-changers, off-load tap-changers, etc, which lead to line or neutral terminals, the corresponding line or neutral terminal shall be denoted by 1 or 2 as appropriate.

In applying this system of terminal and tapping marking for the purpose of drawing winding diagrams, all windings are assumed to be wound in the same direction; thus the polarity between the end points 1 and 2 of all windings on one leg is always the same.

NOTE — For auto-transformers, where two windings of a phase have a common end the markings shall be as given in **2.1.4**.

2.1.3 *Line and Neutral Terminals* — The line terminals of the windings of a three-phase power transformer shall be denoted by reference letter *U*, *V*, *W*. These shall precede the reference numbers referred to in **2.1.2**. Where clarification is necessary these reference letters may also be used before the reference numbers referred to in **2.1.5** and **2.1.6**.

The neutral terminal of a winding having star or zigzag connection shall be denoted by the letter *N* for high voltage and *n* for low voltage winding.

For single-phase transformers, this marking shall not be required.

2.1.4 *Identification of Windings* — The various windings of a transformer shall be denoted by reference numbers which shall precede the reference letters referred to in **2.1.3**. The high-voltage winding shall be denoted by the reference number 1, and the other windings with 2, 3,4,...in descending sequence of their rated voltage.

For auto-transformers where two windings of a phase have a common end, this end shall be marked 2 (*see* Fig. 2c).

NOTE — If several windings have the same rated voltage, their respective numbering shall be agreed between the manufacturer and the purchaser.

2.1.5 *Series/Parallel Connections* — Where phase-windings consist of several parts which may either be connected in series or in parallel, the end points of these parts shall be denoted by the reference numbers 1, 2, 3, 4,... the line or neutral ends of the phase-windings being denoted by 1 and 2 as stated in **2.1.2**.

2.1.6 *Marking of Tappings* — The tappings which lead to on-load tap-changers, off-load tap-changers, etc, shall be marked with numeral character groups in a naturally ascending sequence, the numbers being higher than those at the line and neutral ends and those at the ends of parts of phase-windings for series and parallel connection. The numbering shall commence at the tapping nearest to the end marked 1. The marking of tapped windings which may be reversed shall be based on that connection which gives the highest effective number of turns for the winding connected to the tap-changer.

Tapped windings of auto-transformers between series and common windings, at the end of the series winding, or in fork connection, shall be numbered as if the tapped winding belongs to the series winding.

2.2 Examples

2.2.1 Typical markings for phase-windings are shown in Fig. 1 and illustrate the basic method of numbering as given in **2.1.2**, **2.1.5** and **2.1.6**.

2.2.2 Markings for single-phase transformers are shown in Fig. 2 and illustrate the method of numbering as given in **2.1.2** and **2.1.4**.

2.2.3 Typical markings for single-phase auto-transformers are shown in Fig. 3.

2.2.4 Markings for three-phase, two-winding transformer are shown in Fig. 4.

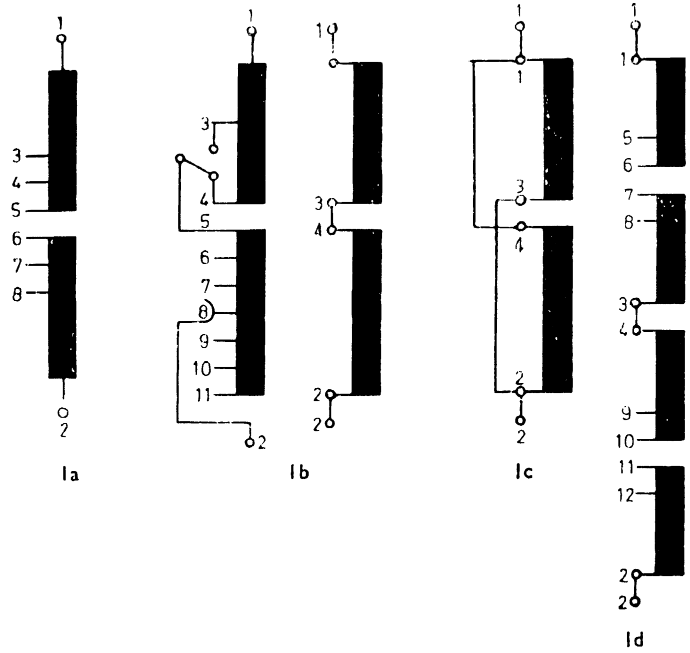
2.2.5 Marking for three-phase three-winding transformer having connection symbol 'YNyn0d5' is shown in Fig. 5.

2.2.6 Marking for the low-voltage winding in Fig. 5, if it is open-delta connection, is shown in Fig. 6.

2.2.7 Marking for three-phase auto-transformer is shown in Fig. 7.

2.2.8 Marking for booster transformer with energizing winding connected in delta is shown in Fig. 8.

NOTE — Figures 4 to 8 illustrate the marking as defined in **2.1.2**, **2.1.3** and **2.1.4** and show where the numeral characters denoting the end points of a phase-winding may be omitted as given in **2.1.1**.



Ia) Phase-winding with mid-winding tappings.

Ib) Phase-winding with coarse step and fine step tappings at one end of winding.

Ic) Phase-winding with two parts for connecting in series or parallel.

Id) Phase-winding with two parts connected in series and each having mid-winding tappings.

FIG. 1 TYPICAL MARKINGS FOR PHASE-WINDINGS

3. TAPPINGS

NOTE 1 — Clauses **3.1** to **3.4.2** are restricted to transformers having only one tapped winding. For auto-transformers this means that the number of turns per phase in either the HV or LV circuit is constant. Auto-transformers with tapped neutral are subject to agreement between the manufacturer and the purchaser. However, some definitions have a wider field of application [*see* **2.5** of IS : 1885 (Part XXXVIII)-1977*].

NOTE 2 — Tap-changing involving a phase displacement in the voltage is not taken into account.

3.1 Requirements Valid for All Categories of Voltage Variation

3.1.1 *General* — Transformers are not provided with tappings unless specifically required. When tappings are required, it shall be stated if they are intended for off-circuit or for on-load tap-changing.

3.1.2 *Principal Tapping* — Unless otherwise specified, the principal tapping is the mean tapping position if the number of tapping positions is odd, or, if this number is even, that one of the two middle tapping

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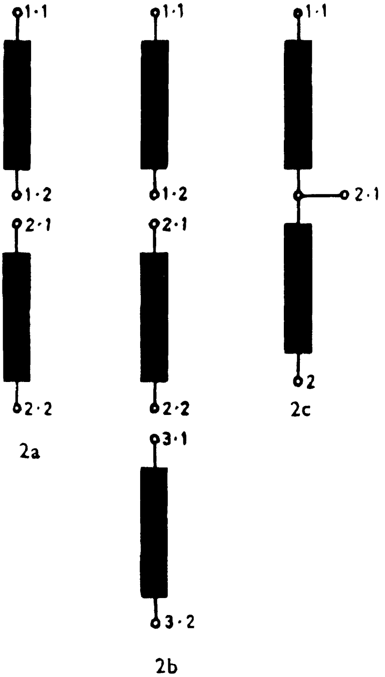
*Electrotechnical vocabulary: Part XXXVIII Transformers (*first revision*).



2a) Two-winding transformer without tappings.
2b) Three-winding transformer without tappings.
2c) Auto-transformer without tappings.

FIG. 2 MARKINGS FOR SINGLE-PHASE TRANSFORMERS

positions which is associated with the higher effective number of turns of the tapped winding; if the tapping thus defined is not a full-power tapping, the nearest full-power tapping shall be chosen [the principal tapping is a full-power tapping in accordance with **2.5.9** of IS : 1885 (Part XXXVIII)-1977*].

3.1.3 *Tapping Range* — The tapping range of the tapped winding shall be expressed as follows:

a) If there are plus tappings and minus tappings : ±*a* percent or +*a* percent, –*b* percent, and

b) If there are only plus tappings or minus tappings : +*a* percent or –*b* percent.

3.1.4 *Short-Circuit Impedance* — The winding(s) to which the impedance is related shall be indicated as follows:

a) For a two-winding transformer, indication of the winding to which

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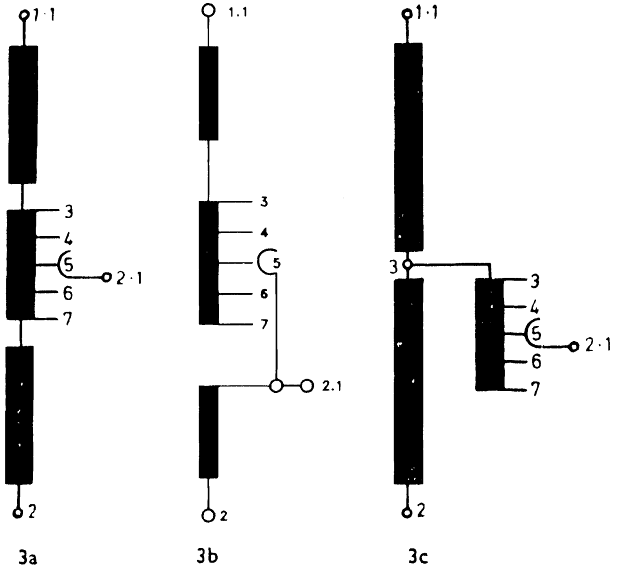
*Electrotechnical vocabulary: Part XXXVIII Transformers (*first revision*).



3a) Tapped winding between series and common winding.
3b) Tapped winding at the end of the series winding.
3c) Tapped winding in fork connection.

FIG. 3 TYPICAL MARKINGS FOR SINGLE-PHASE AUTO-TRANSFORMER

the impedance is related shall suffice (HV impedance, LV impedance), and

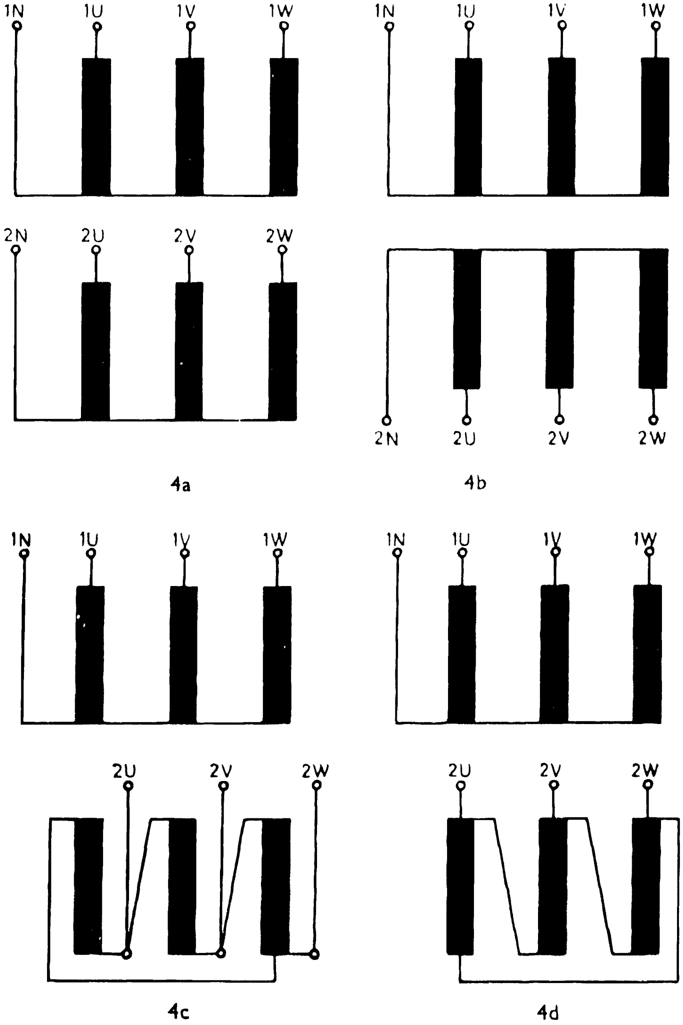
b) For a multi-winding transformer the impedance of the HV/LV windings pair, related to the HV winding for instance, shall be referred to as the HV/LV impedance (HV being underlined) or as the HV impedance of the HV/LV pair.

Depending on system conditions, the impedance may usually be related to either one of the windings. If the power flow is only from the HV winding to the LV winding, it is advisable to relate the impedance to the HV winding.

NOTE — Three-winding transformers and auto-transformers with low-voltage ratio (such as below 2 : 1) need special consideration and in such cases **3.1.4.1** and **3.1.4.2** may not apply.

3.1.4.1 *Principal tapping* — The short-circuit impedance shall be specified in ohms per phase related to one winding in addition to the 'impedance voltage at rated current' expressed as a percentage.

3.1.4.2 *Other tappings* — If necessary, the short-circuit impedances on other tappings may be specified. If this is done, the extreme tapping



4a) YNyn0
4b) YNyn6
4c) YNd5
4d) YNd11

FIG. 4 MARKINGS FOR THREE-PHASE TWO-WINDING TRANSFORMERS

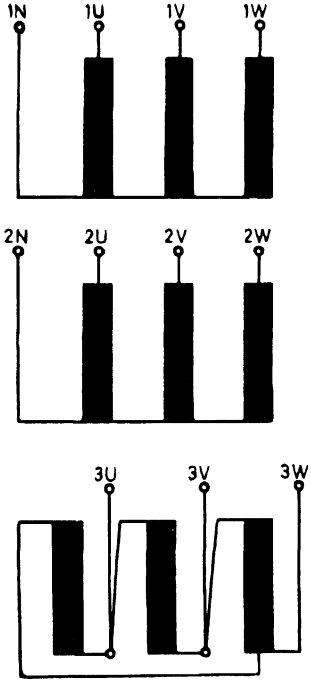


FIG. 5 MARKING FOR THREE-PHASE THREE-WINDING TRANSFORMER (YNyn0d5)

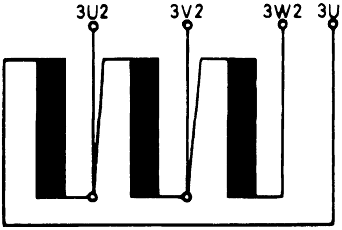


FIG. 6 MARKING FOR THE LOW-VOLTAGE WINDING IN FIG. 5, IF IT IS OPEN-DELTA CONNECTED

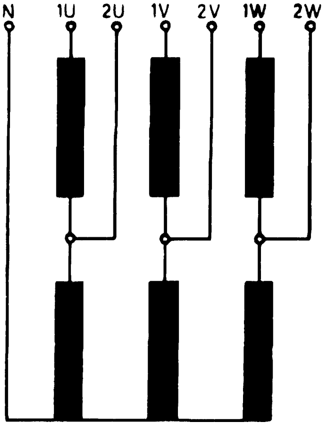


FIG. 7 MARKING FOR THREE-PHASE AUTO-TRANSFORMER (YNa0)

impedances shall be included. The tolerances then applicable shall be as follows:

a) If the principal tapping corresponds with the mean tapping position or with one of the two middle tapping positions, the tolerances applicable on this principal tapping shall be those stated in Table 7 of IS : 2026 (Part I)-1977* and on other than the principal tapping, shall be increased by a percentage equal to half the difference in tapping factor (percentage) between the principal tapping and the actual tapping.

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*Specification for power transformers: Part I General (*first revision*).

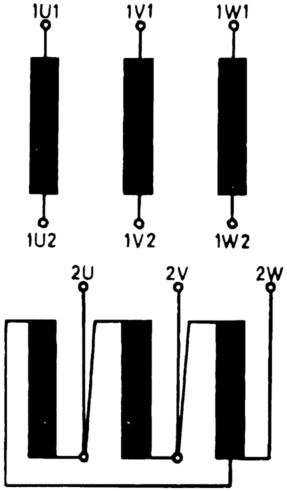

FIG. 8 MARKING FOR BOOSTER TRANSFORMER WITH ENERGIZING WINDING CONNECTED IN DELTA

b) In the other cases the tapping range shall be considered as balanced about the mid-tapping position and the tolerances shall be calculated as before but assuming tolerances according to Table 7 of IS : 2026 (Part I)-1977* applying to the mid-tapping position. This may mean a true tolerance on principal tapping in excess of that in Table 7 of IS : 2026 (Part I)-1977*.

   For a specified tapping range, the simplest method is to fix, according to the above calculation, only the minimum and maximum values of impedance including the tolerances.

NOTE — For tapping ranges in excess of an overall 25 percent of where the tolerances derived may result in unacceptable levels of impedance, tolerances shall be subject to agreement between the manufacturer and the purchaser.

3.1.5 *Load Loss Requirements* — The purchaser shall state for which tapping connections, in addition to that on the principal tapping, values for load loss shall be declared by the manufacturer. They usually include the extreme tappings.

The reference current of two-winding transformer is, for any tapping, equal to the tapping current.

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*Specification for power transformers: Part I General (*first revision*).

For multi-winding transformers the reference current or the reference power shall be stated.

3.1.6 *Requirements Related to Temperature-Rise* (*Guarantees and Tests*) — Temperature-rise limit values are applicable to the tapping position as specified in **3.4** of IS : 2026 (Part 2)-1977 'Specification for power transformers, Part 2 Temperature-rise'. Except in such cases where agreed to between the purchaser and the supplier, the temperature-rise test need be carried out on one tapping only, chosen in accordance with **3.4** of IS : 2026 (Part 2)-1977.

3.1.7 *Requirements Related to Operation at a Voltage Higher than the Tapping Voltage* — For all tappings, requirements shall be the same as for the principal tapping the words 'rated voltage' and 'rated current' being changed into 'tapping voltage' and 'tapping current'.

3.2 Requirements for Constant Flux Voltage Variation (CFVV)

3.2.1 The constant flux voltage variation shall be the voltage variation when the tapping voltage is:

a) rated voltage for any untapped winding, or

b) rated voltage multiplied by the tapping factor for the tapped winding.

NOTE 1 — The magnetic-flux (at no-load) is the same for all tapping positions, thus the name constant flux variation.

NOTE 2 — Figure 9a shows the variation of the tapping voltage as a function of the tapping factor.

3.2.2 *Additional Requirements for CFVV*

3.2.2.1 Specifications shall indicate (*see* **A-1**):

a) the category of voltage variation CFVV,

b) the rated power of the transformer or the rated power of each winding in the case of a multi-winding transformer,

c) the rated voltages,

d) which winding is the tapped winding, and its tapping range,

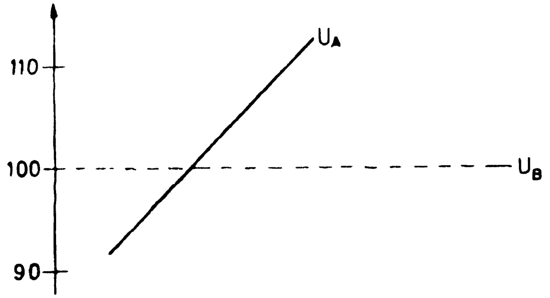
e) the number of tapping positions, or the tapping step. In the first case, the tapping steps shall be supposed to be approximately equal.

NOTE — Whenever nothing is indicated on the category of voltage variation, category CFVV is assumed to be applied.

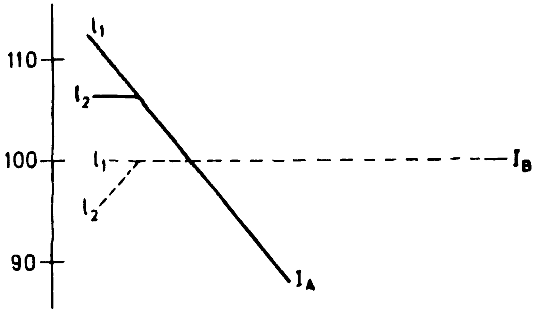
3.2.2.2 *Tapping currents and tapping power* (*see Fig. 9b and 9c*) — If nothing is specified, it is implied that all tappings are full-power tappings.

If a 'maximum current tapping' is specified, it is implied that above this tapping (higher tapping factors) the tappings are full-power tappings and that below this tapping the tapping current is constant for the tapped winding whence a reduced tapping power.

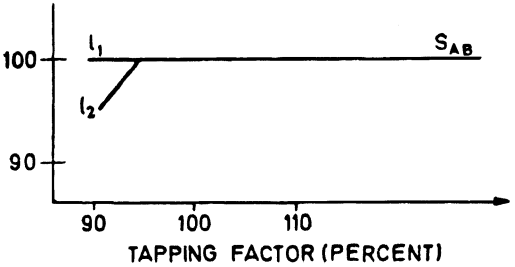
NOTE 1 — In the first case (only full-power tappings) the extreme minus tapping may be called 'maximum current tapping'.



9a Tapping Voltage



9b Tapping Current



9c Tapping Power

U — Tapping voltage
I — Tapping current
S — Tapping power

The subscript A refers to the tapped winding.
The subscript B refers to the untapped winding

FIG. 9 CONSTANT FLUX VOLTAGE VARIATION
(With constant power l_1 in Fig. 9b and 9c, and with limited current l_2 in Fig. 9b and 9c)

3.2.3 *Separate Winding Transformers of Rated Power up to 3 150 kVA and a Tapping Range up to ± 5 Percent* — Unless otherwise specified:

a) the principal tapping shall be the maximum current tapping (tapping current of the tapped winding equal to rated current for all the minus tappings), and

b) the short-circuit impedance and load loss guarantees shall relate, only to the principal tapping.

3.3 Requirements for Variable Flux Voltage Variation (VFVV)

3.3.1 Variable flux voltage variation shall be the voltage variation when the tapping voltage is constant for the tapped winding (and equal to its rated voltage) (*see* Fig. 10a).

3.3.2 *Additional Requirement for VFVV*

3.3.2.1 Specifications shall indicate (*see* **A-2**):

a) category of voltage variation: variable flux voltage variation (VFVV);

b) the rated power of the transformer or the rated power of each winding in the case of a multi-winding transformer;

c) the rated voltages; for each untapped winding the extreme tapping voltages shall be specified and the rated voltage underlined;

d) which winding is the tapped winding and what is its tapping range; and

e) the number of tapping positions or the tapping step.

3.3.2.2 *Tapping currents and tapping power* (*see* Fig. 10b and 10c) — If nothing is specified, it shall be implied that all tappings are full-power tappings. If a 'maximum current tapping' is specified, it shall be implied that below this tapping (lower tapping factors) the tappings are full-power tappings and that above this tapping, the tapping current is constant for the untapped winding.

3.3.2.3 *Requirements related to no-load loss and no-load current* — The following shall be agreed between the manufacturer and the purchaser:

a) For which tappings (other than the principal tapping) values of no-load losses shall be stated by the manufacturer and for which tappings value of no-load current shall be stated, and

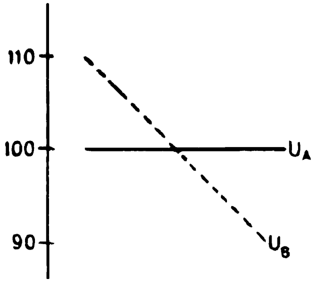
b) The voltages to be considered for those tappings.

3.4 Requirements for Combined Voltage Variation (Cb.VV)

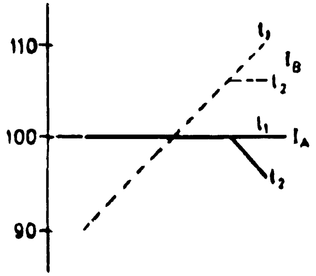
3.4.1 Combined voltage variation shall be the voltage variation which combines as follows CFVV and VFVV (*see* Fig. 11a):

a) Below a certain value of the tapping factor, the tapping voltages vary (as in CFVV); and

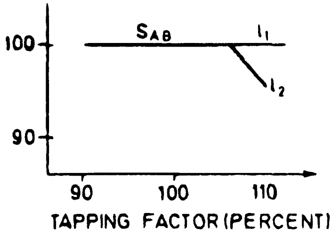
b) Above this value the tapping voltage of the tapped winding is constant (as in VFVV).



10a Tapping Voltage



10b Tapping Currents



10c Tapping Power

U — Tapping voltage
I — Tapping current
S — Tapping power

The subscript A refers to the tapped winding.
The subscript B refers to the untapped winding.

FIG. 10 VARIABLE FLUX VOLTAGE VARIATION
(With constant power l_1 in Fig. 10b and 10c, and
with limited current l_2 in Fig. 10b and 10c)

The tapping corresponding to this value of the tapping factor is called 'maximum voltage tapping'.

3.4.2 *Additional Requirements for Cb.VV*

3.4.2.1 Specifications shall indicate:

a) the category of voltage variation : Cb.VV;

b) the rated power of the transformer or the rated power of each winding in the case of a multi-winding transformer;

c) the rated voltages;

d) which winding is the tapped winding, and its tapping range;

e) the number of tapping positions or the tapping step; and

f) which tapping is the 'maximum voltage tapping' with the corresponding tapping voltages (*see* Fig. 11a).

3.4.2.2 *Tapping currents and power* — If a 'maximum current tapping' is specified, with the corresponding tapping currents, it shall be implied that below this tapping (lower tapping factors) the tapping current is constant for the untapped winding (*see* Fig. 11b). This tapping, the maximum voltage tapping and the intermediate tappings shall be the full-power tappings. The other tappings shall be reduced-power tappings (*see* Fig. 11c).

NOTE — The information considered in **3.4.2.1**(a) and **3.4.2.1**(b) may be given in a table as in **A-3**.

3.4.2.3 *Requirements related to no-load loss* — These shall be the same as in **3.3.2.3**.

4. CONNECTIONS

4.1 Connections of Phase-Windings — The star, delta, or zigzag connection of a set of phase-windings of a three-phase transformer or of windings of the same voltage of single-phase transformers associated in a three-phase bank shall be indicated by the letters Y, D or Z for the high-voltage winding and y, d or z for the intermediate and low-voltage windings. If the neutral point of a star or a zigzag connected winding is brought out, the indication shall be YN or ZN and yn or zn respectively.

For the auto-transformer in which the two windings have a common part, the winding of the pair which has the lower rated voltage is indicated by the letter a.

4.2 Phase Displacement Between Windings — The vector relating to the high-voltage winding shall be taken as the vector of origin. Examples of vector diagrams showing the use of the clock-hour figure [*see* **2.10.8** of IS : 1885 (Part XXXVIII)-1977*] are given in Fig. 12.

For multi-winding transformers, the vector for the high voltage winding remains the reference vector and the symbol for this winding shall be given first. Other symbols shall follow in diminishing sequence of rated voltages of the other windings.

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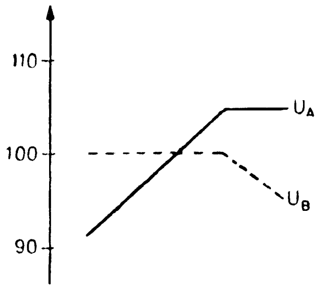
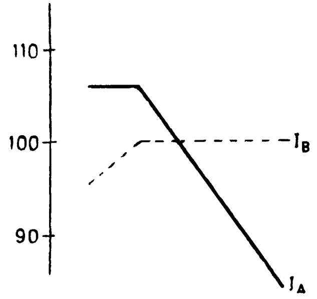
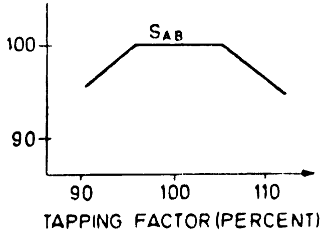
*Electrotechnical vocabulary : Part XXXVIII Transformers (*first revision*).



11a Combined Voltage Variation



11b Tapping Currents

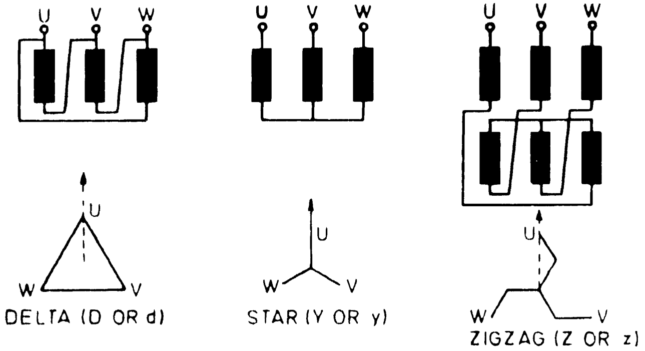


11c Tapping Power

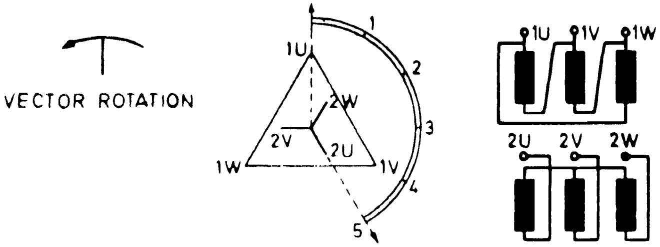
U — **Tapping voltage**
I — **Tapping current**
S — **Tapping power**

The subscript A refers to the tapped winding.
The subscript B refers to the untapped winding.

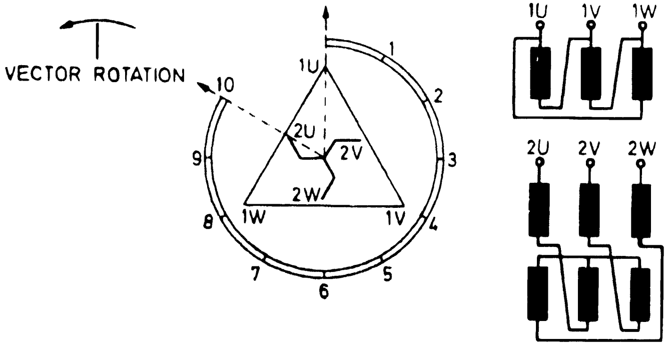
FIG. 11 COMBINED VOLTAGE VARIATION



12a Delta, Star or Zigzag Connected Winding



12b Connection Symbol Dy5



12c Connection Symbol Dz10

FIG. 12 ILLUSTRATIONS OF THE USE OF CONNECTION SYMBOLS

In the case of auto-transformers in which two windings have a common part, the letter *a*, which corresponds to the winding with the lower rated voltage of the pair, shall be written after the letter corresponding to the winding with the higher rated voltage of the pair, for instance *YNaod*11 (the pair of auto-connected windings includes the winding with the higher rated voltage or *Dyni*1) (the pair of auto-connected windings does not include the high-voltage winding).

NOTE — Appendix B gives details of a number of connections that are in general use, but it does not purport to be complete.

Examples:

1) In the case of a transformer with three windings respectively for 150 000 V (delta), 60 000 V (star with neutral point not brought out) and 10 000 V (star with neutral point not brought out), the designation (for the case where the two-star voltages are in phase with one another and lag by 30° on the delta voltage) would be:

   *Dy*1*y*1

2) In the case of another transformer with three windings respectively for 6 000 V (star with neutral point brought out), 380 V (star with neutral point not brought out) and 220 V (zigzag with neutral point not brought out), the designation (for the case where the two-star voltages are in phase with one another and the zigzag voltage lags by 30°) would be:

   YNyozi

NOTE — In practice, due in particular to the rules laid down in **4.2**, no confusion shall arise if, in data transmission, only capital or small letters are used.

APPENDIX A

(*Clauses* 3.2.2, 3.3.2 *and* 3.4.2)

EXAMPLES OF SPECIFICATIONS FOR TRANSFORMERS FITTED WITH TAPPINGS

A-1. CONSTANT FLUX VOLTAGE VARIATION

A-1.1 Example with Two Variants:

Transformer having a 66/20 kV, 3 phase, 40 MVA rating and a ±10 percent tapping range on the 66 kV winding, with 11 tapping positions.

a) *First variant* : All tappings are full power tappings
Category of voltage variation : CFVV
Rated power : 40 MVA
Rated voltages : 66/20 kV
Tapped winding : 66 kV—tapping range ±10 percent
Number of tapping positions : 11

b) *Second variant* : With reduced power tappings : add
Maximum current tapping : tapping –5 percent

NOTE — Unless additional specifications are given, the tapping current of the HV winding is then limited to 368 amperes from the tapping –5 percent to the extreme tapping –10 percent where the tapping power is reduced to 38 MVA.

A-2. VARIABLE FLUX VOLTAGE VARIATION

A-2.1 Transformer having a 66/6 kV, 3 phase, 20 MVA rating and a +15 percent –5 percent tapping range on the HV winding, but having a constant tapping voltage for the HV winding and a variable tapping voltage for the LV winding, between

$$\frac{6}{0.95} = 6.32 \text{ and } \frac{6}{1.15} = 5.22 \text{ kV}$$

Variant 1 : There are only ‘full power tappings’ :
Category of voltage variation : VFVV
Rated power : 20 MVA
Rated voltages : 66/6 kV
Tappings on winding : 66 kV (tapping range +15 percent –5 percent)
Tapping voltages of 6 kV winding : 6.32, 6 and 5.22 kV
Number of tapping positions : 11

Variant 2 : With reduced power tappings shall be added :
Maximum current tapping : tapping +5 percent

NOTE — The ‘tapping current’ of the untapped winding (LV) is then limited to 2 020 amperes from the tapping +5 percent to the extreme tapping +15 percent where the tapping power is reduced to 18.2 MVA.

A-3. COMBINED VOLTAGE VARIATION

A-3.1 The specifications may be stated in a tabular form as given in Table 1.

A-3.1.1 The ‘maximum voltage tapping’ is the tapping +6 percent.

A-3.1.2 The ‘maximum current tapping’ is the tapping –9 percent.

TABLE 1 COMBINED VOLTAGE VARIATION RATING 160/20 kV, 40 MVA, 3-PHASE, TAPPED WINDING: XV — TAPPING RANGE ±15 PERCENT NUMBER OF TAPPING POSITIONS : 21

(*Clause* A-3.1)

TAPPINGS	VOLTAGE RATIO	TAPPING VOLTAGES		TAPPING CURRENT		TAPPING POWER
		U_{HV}	U_{LV}	I_{HV}	I_{LV}	
(1)	(2)	(3) kV	(4) kV	(5) A	(6) A	(7) MVA
1(+15%)	9.20	169.6	18.43	125.6	1 155	36.86
Intermediary	Decreasing	169.6	Increasing	Increasing	1 155	Increasing
7 (+6%)	8.48	169.6	20	136.2	1 155	40
Intermediary	Decreasing	Decreasing	20	Increasing	1 155	40
15 (–9%)	7.28	145.6	20	158.7	1 155	40
Intermediary	Decreasing	Decreasing	20	158.7	Decreasing	Decreasing
21 (–15%)	6.80	136	20	158.7	1 080	37.4

NOTE 1 — In completing the intermediate lines the preceding table may be used on a rating plate.

NOTE 2 — Compare these specifications and 'CFVV' specifications which would be:

160±15 percent/20 kV, 40 MVA

The only difference is that the HV tapping voltage does not exceed the 'system highest voltage' of the HV system, which is 170 kV.

There is no difference in the currents.

APPENDIX B

(*Clause* 4.2)

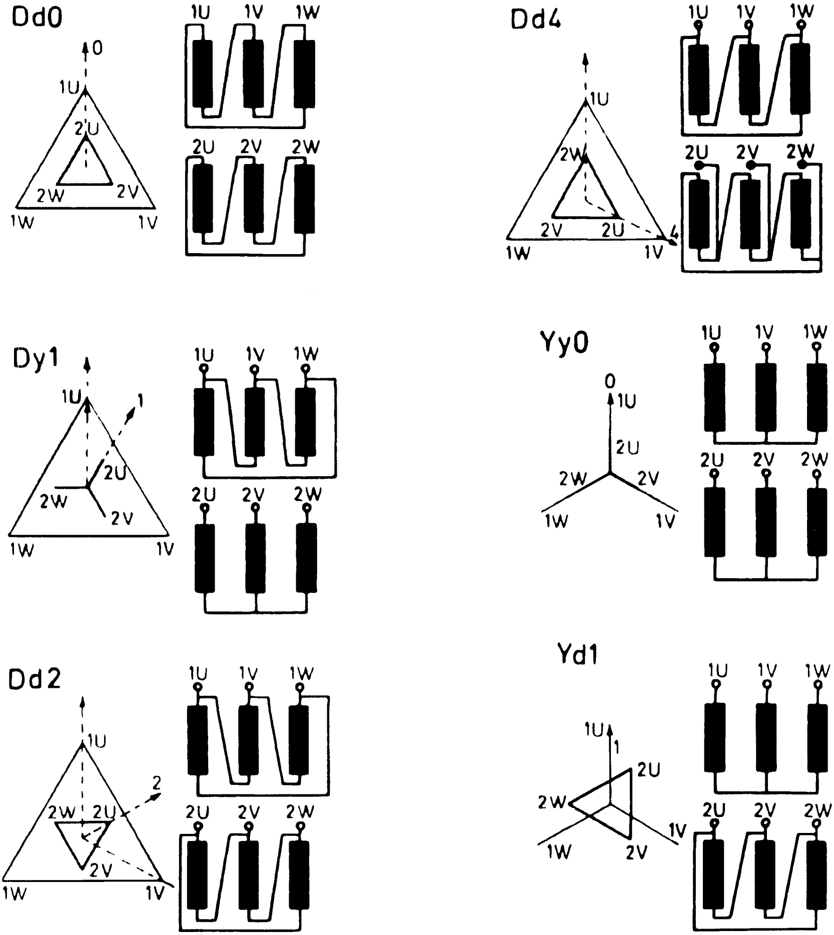
TRANSFORMER CONNECTIONS IN GENERAL USE

B-1. THREE-PHASE TRANSFORMERS

B-1.1 Separate Winding Transformers — Figures 13a and 13b give details of three-phase transformer connections that are in general use and the angle of phase shift associated with them. The connection diagram assumes the same winding direction for all windings.

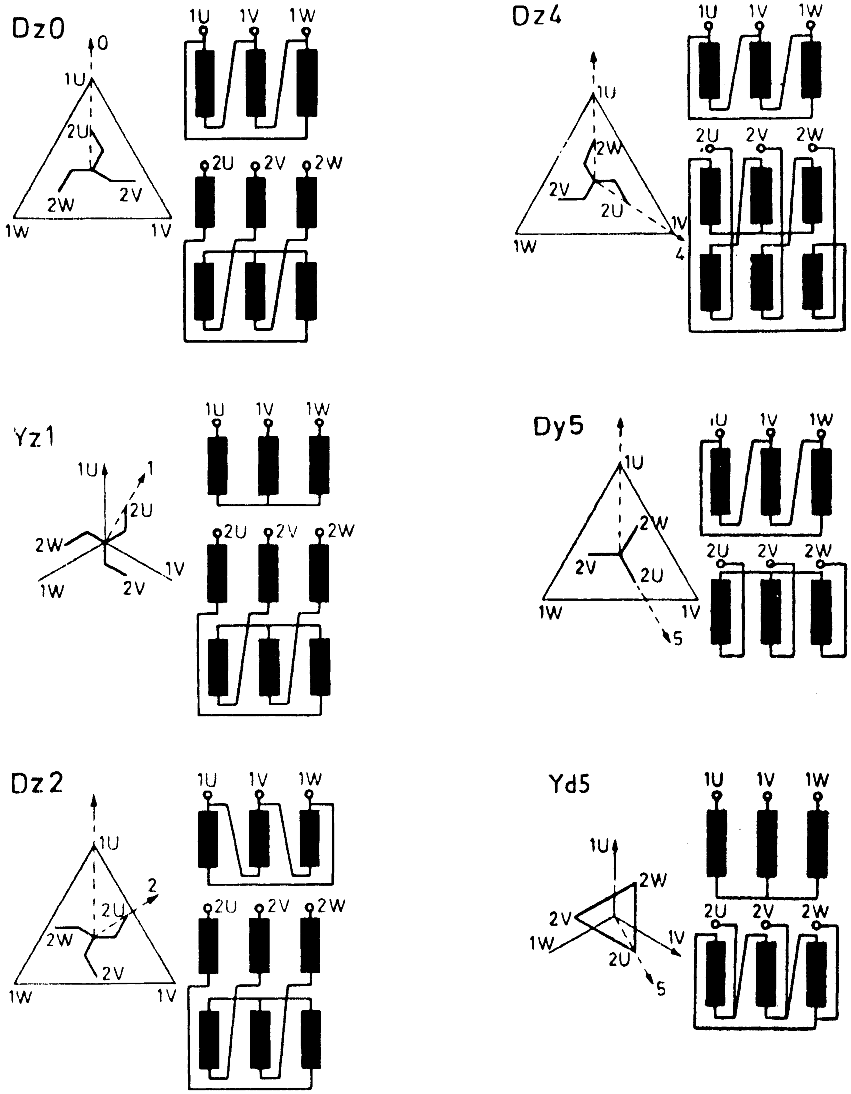
B-1.2 Auto-transformers — It should be remembered that phase displacements different from clock-hours 0, 4 and 8 are not suitable for use with star-connected auto-transformers.

Figure 13c is limited to the connection symbol *Yao*.



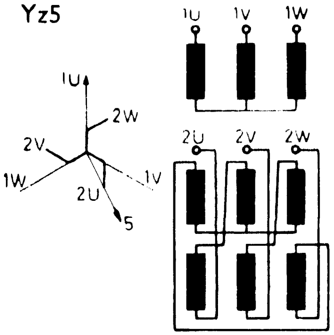
13a Separate Winding Transformers Hour Numbers from 0 to 5

(*Continued*)

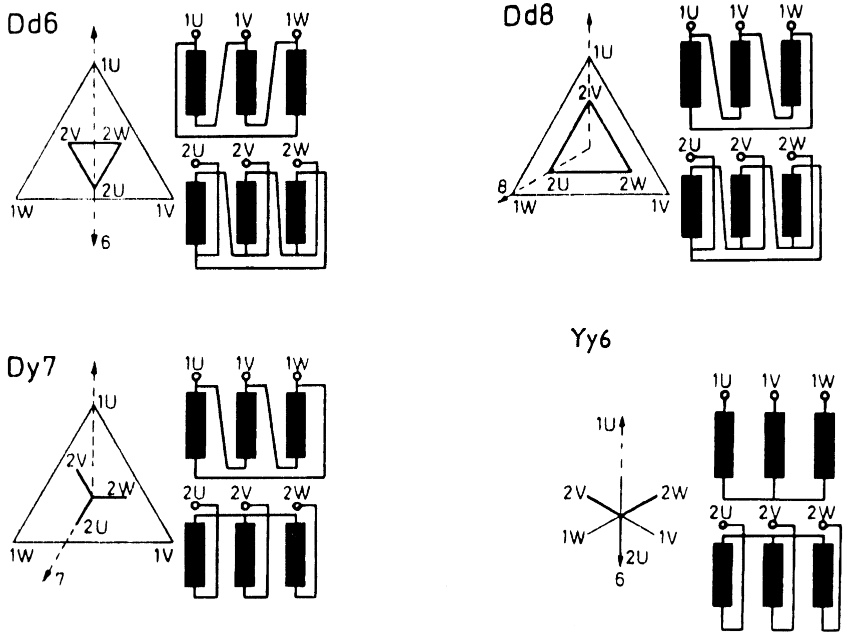


13a Separate Winding Transformers Hour Numbers from 0 to 5

(Continued)

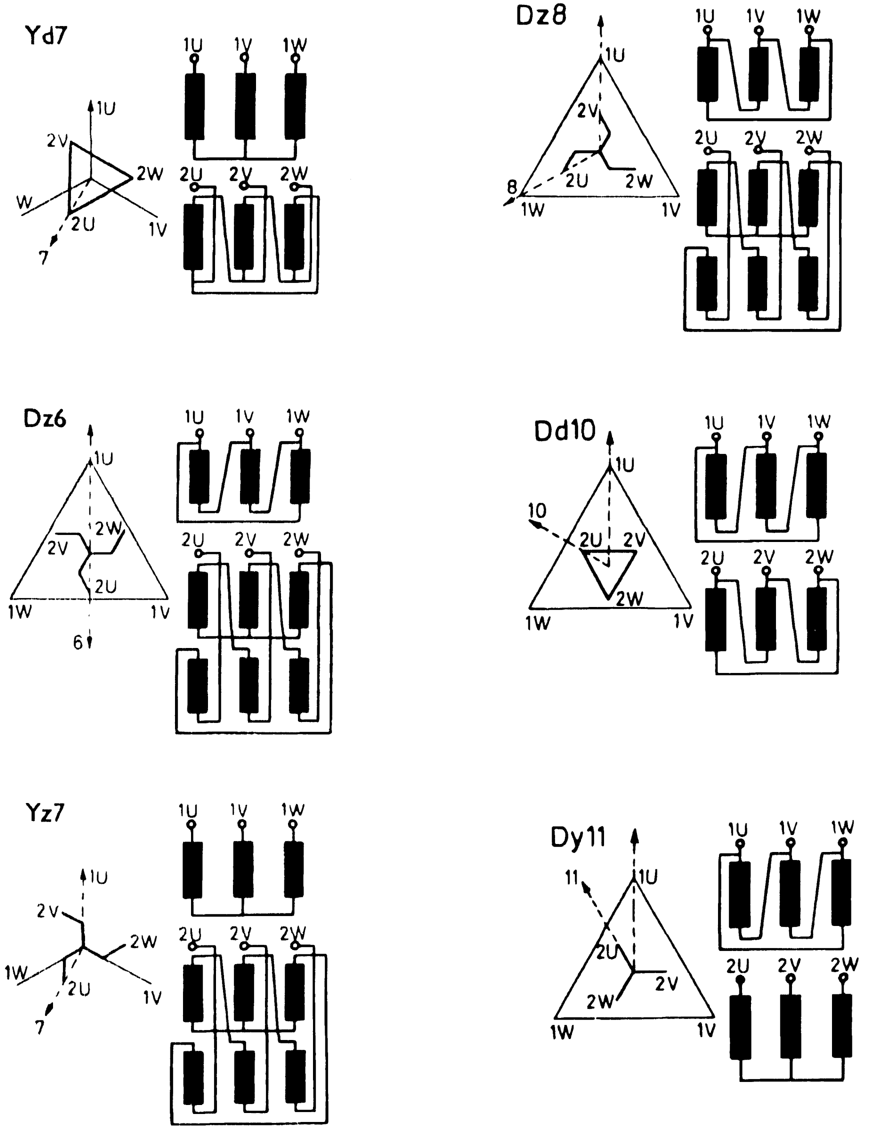


13a Separate Winding Transformers Hour Numbers from 0 to 5



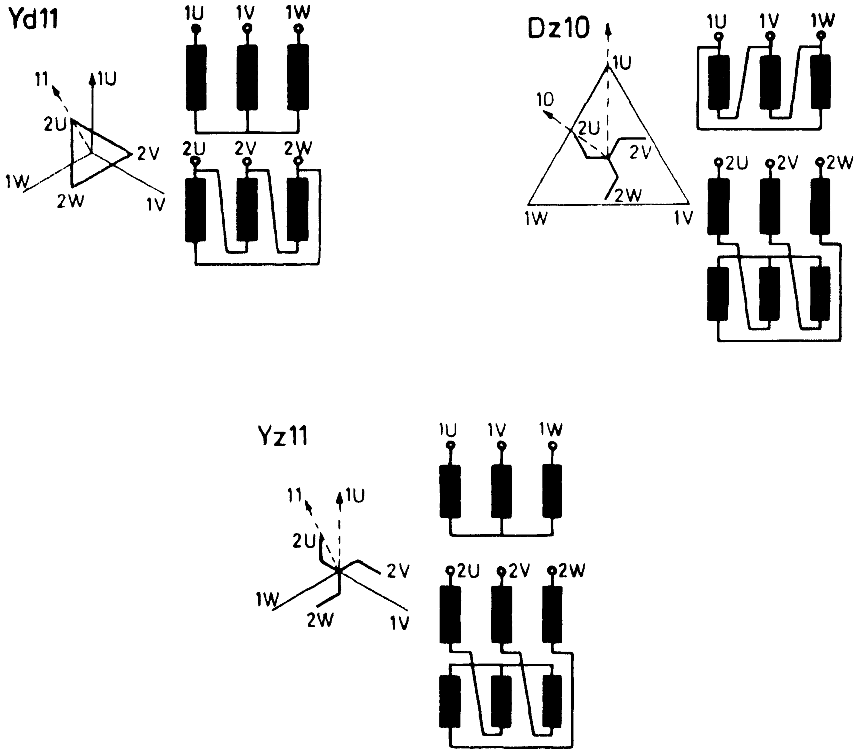
13b Separate Winding Transformers Hour Numbers from 6 to 11

(*Continued*)

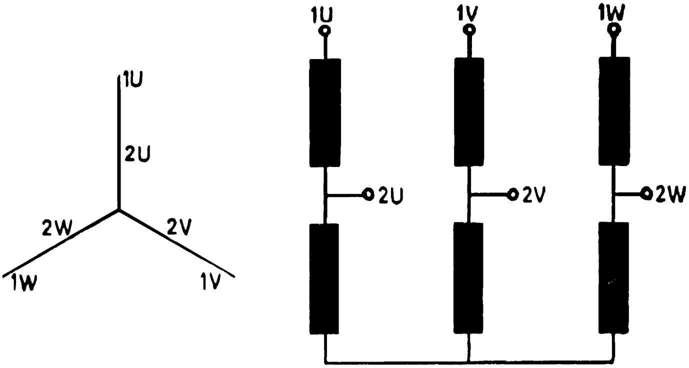


13b Separate Winding Transformers Hour Numbers from 6 to 11

(Continued)



13b Separate Winding Transformers Hour Numbers from 6 to 11



13c Auto-transformers Yao

FIG. 13 DESIGNATION OF CONNECTIONS OF THREE-PHASE TRANSFORMERS BY CONNECTION SYMBOLS

B-2. EXAMPLE OF THREE SINGLE-PHASE TRANSFORMERS CONNECTED TO FORM A THREE-PHASE BANK

B-2.1 In this case, both ends of each winding of each single-phase transformer are brought out to terminals and given markings. A diagram of such a three-phase bank is given in Fig. 14, by way of example; in which the corresponding terminals are called 1 *U* and 2 *U* for the first single-phase transformers, 1 *V* and 2 *V* for the second one, 1 *W* and 2 *W* for the third one.

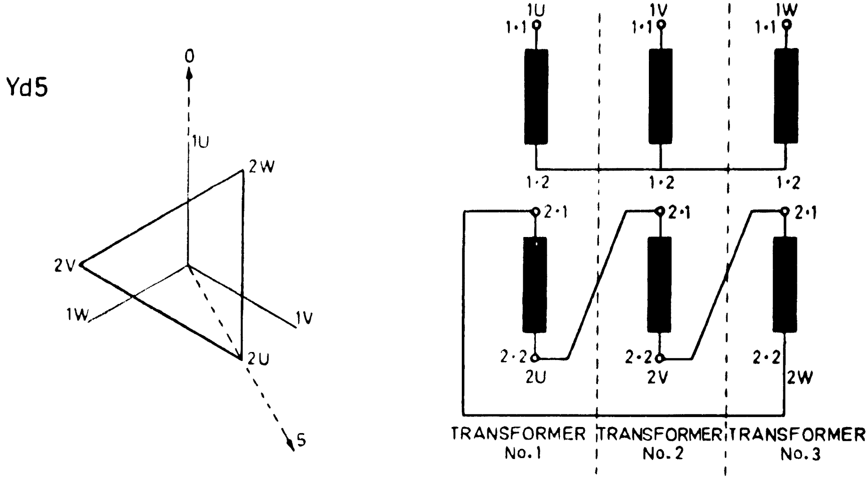


Fig. 14 Example of Three Single-Phase Transformers Connected to Form a Three-Phase Bank (Connection Symbol Yd5)

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